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## Correlation between Hemoglobin Levels and Muscular Endurance in Soccer Athletes

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### ABSTRACT

**Background:** Muscular endurance is one of the important component of physical fitness in the sport of soccer player. Soccer athletes are required to contracting the muscle explosively as maximum as possible and must have high aerobic capability. This study aimed to determine the correlation between hemoglobin levels with muscular endurance in soccer athletes.

**Subjects and Method:** This was an analytic observational study with cross sectional design. Population was soccer player athlete who was incorporated in soccer clubs and soccer schools at Medan, North Sumatera, Indonesia. A sample of 96 soccer athletes was selected for this study. The dependent variable was muscular endurance. The independent variables were hemoglobin levels. Hemoglobin level was measured by cyanmethemoglobin method, and muscular endurance was measured by push-up test. The data was analyzed by using Spearman test.

**Results:** Hemoglobin levels was positively correlated with muscular endurance levels and it was statistically significant ( $r = 0.226$ ;  $p < 0.05$ ).

**Conclusion:** This study showed hemoglobin levels correlates with muscular endurance.

**Keywords:** hemoglobin, muscular endurance, soccer athletes

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### BACKGROUND

Sports is one physical activity that can increase physical fitness. Exercise involves several systems other than the musculo-skeletal system, such as the cardiovascular system, respiratory system, nervous system, excretory system, and several other systems (Mutohir and Maksum, 2007). Physical fitness can cause a decrease in speed and skills in ball games (Husaini et al., 2002). A person's physical abilities are influenced by a combination of several factors, namely internal factors and external factors. Internal factors such as genetic factors, age, and gender, while external factors are physical activity, nutritional status, health status, hemoglobin level, adequacy of rest, and smoking habits (Ahmetov and Fedotovskaya, 2015).

The ability to maintain muscular activity in a longer time is called muscular endurance (Katch et al., 2011). Muscle endurance is one component of physical fitness, in addition to strength, cardiovascular endurance, muscle flexibility, agility, speed, balance, reaction speed, body composition, and coordination (Rink et al., 2010; US Department and Human Service, 2011). Factors that determine muscle endurance are the ability of mitochondrial oxidation, ATP synthesis, muscle fiber type, and vascularization (Yan et al., 2011; Kenny et al., 2012).

Increased blood flow to skeletal muscle is needed in physical activity to provide an additional supply of oxygen and nutrients, which is not only obtained from increased cardiac output (Prior et al.,

2004). As endurance athletes who mostly use aerobic energy sources through oxidative phosphorylation, endurance athletes need higher maximal oxygen absorption ( $VO_{2max}$ ), compared to sprints and sports that use power (Lucia et al., 2005).

This study is to assess the correlation of hemoglobin levels with muscle endurance in soccer athletes.

### SUBJECTS AND METHOD

This was an analytic observational study with a cross sectional design. The study population is soccer athletes who are members of the Football Club and Football School (SSB) in the city of Medan. The sampling was done by consecutive sampling technique. A sample of 96 soccer athletes aged 15-29 years old undergoing regular soccer training was selected for this study. The study subjects voluntarily signed an informed consent form and received approval from the Ethics Commission of the Faculty of Medicine, Universitas Sumatera Utara, Indonesia.

Hemoglobin levels were measured by cyanmethemoglobin. Hemoglobin levels are

classified as low if  $<13$  g% and normal if 13-16 g% (WHO, 2001).

Push-up tests were used to determine the endurance of the study subject's muscle. Assessment of the push-up test was done by counting the total number of push-ups that can be done for one minute. The data were analyzed by Prism 7 software (GraphPad Software Inc.).

### RESULTS

The subjects of the study were soccer athletes who were members of several football clubs between the ages of 15-21 years and male players who did soccer practice routinely  $\pm 3$  times a week guided by the coach.

In this study, the subjects were classified based on Hb levels into 2 groups, normal Hb and less Hb (anemia). Most of the subjects (77.1%) had normal hemoglobin levels (Table 1) and 22.9% of them had low Hb. Based on the amount of ability to do push-ups per minute, the muscle endurance of the subjects was classified into five groups. 51% of subjects showed very good muscle endurance and 22.9% showed less muscle endurance (Table 2).

**Table 1. Distribution of hemoglobin levels**

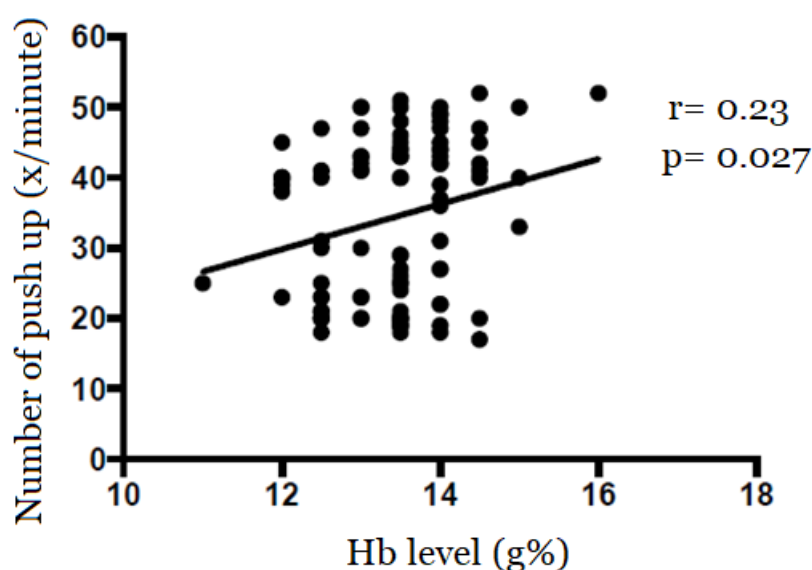
Hemoglobin level	N	(%)	Mean Hb (g %)	SD
Lacking	22	22.9	12.27	0.37
Normal	74	77.1	13.76	0.58

**Table 2. Distribution of muscle endurance**

Muscle endurance	N	(%)	Mean of total push-up (x/minute)	SD
Very poor	1	1.0	17.00	
Poor	22	22.9	19.86	1.13
Fair	14	14.6	24.71	1.59
Good	10	10.4	32.40	3.41
Very good	49	51.0	44.43	3.85

The results of this study showed that there was a positive correlation between

hemoglobin levels and muscle endurance ( $r = 0.23$ ;  $p = 0.027$ ).



**Figure 1. Correlation of hemoglobin levels with muscle endurance**

## DISCUSSION

The results of this study showed that hemoglobin level was positively correlated with muscle endurance among soccer athletes ( $r = 0.23$ ;  $p = 0.027$ ).

Factors that determined muscle endurance were the ability of mitochondrial oxidation, adenosine triphosphate (ATP) synthesis, muscle fiber type, and vascularization (Yan et al., 2011; Kenny et al., 2012). Mitochondrial dysfunction in muscles, caused several conditions such as muscle atrophy, diabetes, and aging (Schrauwen-Hinderling et al., 2007; Figueiredo et al., 2008; Romanello et al., 2010).

Upregulation of mitochondrial number and function, also referred to as mitochondrial biogenesis, played an important role in exercises that cause increased muscle function and metabolic homeostasis throughout the body (Lanza et al., 2008; Lira et al., 2010). Cells can store very limited amounts of ATP and gradually produce new ATP to provide energy requirements for all cellular metabolism including muscle contraction. Cells produced ATP through one or a combination of three

metabolic pathways, namely the ATP-PCr system, the glycolytic system, and the oxidative system (Kenny et al., 2012). Skeletal muscle consists of type I muscle fibers (slow-twitch) and type II muscle fibers (fast-twitch), which have differences in the ability to shorten speed and produce maximum strength. Slow-twitch type I muscle fibers were rich in mitochondria so that fatty acid oxidation was more dominant in mitochondria used for ATP production. While type II muscle fibers (fast-twitch) were more dominant in glucose as an energy substrate. The proportion of type I muscle fibers was positively related to insulin sensitivity and glucose transport by insulin. In parallel endurance training increased the proportion of oxidative fibers with mitochondrial biogenic responses, and was associated with increased physical exercise, fatty acid oxidation and glucose, and energy use (Gan et al., 2013). Increased blood flow to skeletal muscle was needed in physical exercise to provide an additional supply of oxygen and nutrients, which was not only obtained from increased cardiac output. The main vascular adaptation of skeletal

muscle to endurance exercise included an increase in blood flow capacity due to increased cross-section of large blood vessels and increased muscle capillary through angiogenesis. Angiogenesis triggered by endurance training was influenced by several factors, namely, growth factors, hypoxia, and mechanical stress (Prior *et al.*, 2004).

A study by Saunders *et al.*, (2013) among 145 elite athletes showed that there was an increase of VO<sub>2</sub>max with hemoglobin levels. Mahastuti (2018) also obtained results that there was a significant relationship between hemoglobin levels and physical fitness carried out on basketball athletes at Universitas Negeri Semarang, Indonesia. The cardiovascular system fulfilled the needs of the substrate needed by muscles during physical activity. Physical exercise can increase total hemoglobin mass by triggering erythropoiesis and increasing the number of red blood cells 2,3-Bisphosphoglyceric acid (2,3-DPG) which can increase affinity sensitivity Hb-O<sub>2</sub> (Cerretelli and Di Prampero, 1985). With increasing VO<sub>2</sub>max can also increase muscle endurance (Katch *et al.*, 2011). In this study, VO<sub>2</sub>max test was not performed. Researchers suspected that the increase in hemoglobin was accompanied by an increase in VO<sub>2</sub>max, explaining the relationship between hemoglobin and muscle endurance. Based on the results of this study concluded that hemoglobin levels has a relationship with muscle endurance in soccer athletes.

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